1. **NAME OF INITIATIVE:** FLARE-Off-Axis (FLARE = Fermilab Liquid Argon Experiments)

List of major collaborating institutions (including non-US partners).
Duke, Fermilab, Katowice(Poland), MSU, Pisa (Italy), Pittsburgh, Princeton, South Carolina, Texas A&M, Tufts, UCLA, Warsaw (Poland), York (Canada)

2. **SCIENTIFIC JUSTIFICATION:**

Physics goals. How does it fit into the global physics goals for the entire field.
A Liquid Argon Time Projection Chamber is a unique class of advanced detectors offering very significant advantages over the more traditional ones. Its very high granularity and spatial resolution leads to a performance level similar to the bubble chamber. A Liquid Argon TPC, even located at the surface, offers a broad spectrum of physics to be addressed:

- Search for and studies of ν_μ -> ν_e oscillations.

  These studies will provide a complete picture of neutrino mixing and oscillations. They will determine the hereto unknown mixing angle q13, related to the ν_e content of the mass eigenstate ν_3. Energy level shifts induced by matter traversed by neutrino beam may enable determination of the pattern of neutrino masses (hierarchy). Comparison of the oscillation probability for neutrinos and antineutrinos may provide an evidence for CP violation in the lepton sector. Determination of the CP-violating phase of the neutrino mixing angle will likely require, depending on the initial results, an upgraded neutrino beam produced by the Proton Driver or a new neutrino beam with longer baseline.
- High resolution studies of ν_μ disappearance

  The mixing angle θ_{23} is surprisingly large. It may, in fact, be maximal, hence indicating that some new symmetry is at work. Precise determination of the mixing angle θ_{23} and correlated value of Δm_{23} will be enabled by the high resolution provided by the proposed detector. This measurement will require a significant improvement of the knowledge of low energy neutrino interactions.
- Search for nucleon decay

  Nucleon stability is implied by the baryon number conservation. This is the last of the discrete symmetries still standing. But it may be, like all others, be violated in Nature, as expected in Grand Unification schemes. Very stringent limits on nucleon stability are provided by the massive SuperK experiment. The expected nucleon decay modes depend on the supermultiplet structure at the GUT scale. It may well be that dominant decay modes are involving kaons which are not detected with high efficiency in water Cherenkov detectors. The proposed experiment will increase the sensitivity of the search by more than an order of magnitude. Good understanding of the background rejection in a surface detector is necessary.
- Supernova neutrinos

  Supernova explosions provide a unique laboratory for particle physics and astrophysics. Complete physics information consists of the time evolution and energy spectra of fluxes of different neutrino species. The proposed detector will take advantage of the charged current reactions with Argon to separate the ν_e and anti-ν_e fluxes from the other types of neutrinos. Good understanding of the cosmogenically produced background is necessary.

3. VALIDATIONS FOR SCIENTIFIC JUSTIFICATION:

Examples of recommendations and supporting statements from the committees, panels, and the community at large.

Neutrino mass and oscillation problem is included as an important issue in every review of the status of high energy physics:

- Recommendations from the Multi-Divisional Study of the Physics of Neutrinos are a good recent example.
- The Physics of the Universe: A report of the Interagency Working Group on the Physics of the Universe
- Quantum Universe: DOE/NSF High Energy Physics Advisory Panel

4. DESIRED SCHEDULE:

List major milestones (month & year) such as design complete, construction start, construction complete, etc.

Realistic schedule will be dictated by the realities of the approval process and the availability of the construction funds.

Initial engineering studies to validate the design and cost estimates, proposal – June 2005

Review process, approval	June 2006
Start construction	October 2007
Construction complete, start data taking	December 2009

5. ROUGH ESTIMATE OF COST RANGES:

Whatever the best information available (eg. $M +/-30~50%, $150~250M, etc.). Total cost range including non-DOE funding (if any other funding sources are assumed and if known, state from where and how much. Also indicate remaining R&D cost to go.

Total cost: 100-150M.

The cost includes:

- Commercially provided storage tank, liquid argon, cryogenics and purification systems ~ 50M
- High voltage, wire chambers and data acquisition systems ~ 50 M
- Contingency ~ 50M

6. DESIRED NEAR TERM R&D:

Major activities needed to be completed before start construction.

- Detailed engineering of the inner detector.
- Construction of a prototype of a large area wire chamber
- Detailed engineering of the purification and re-circulation system.

- Studies of the importance of the materials cleaning and handling on the attainable argon purity levels
- ASIC implementation of the ICARUS readout electronics. Development of a cold version of electronics is very desirable.
- Detailed studies of the cosmic ray-related backgrounds for nucleon decay and Supernova studies

7. BRIEF DESCRIPTION OF LABORATORY'S ANTICIPATED ROLE:

Expected unique capabilities to be provided by lab. Rough estimate of human resources from lab (#FTE in what type labor).

This experiment is exploiting the physics capabilities of the newly constructed NuMI neutrino beam. The advantage of the NuMI beam over other beams under construction is the combination of beam energy and the baseline, thus allowing the use of matter effects to determine the mass hierarchy.

Construction of a very large liquid argon detector is made possible by a unique combination of the Fermi lab's expertise in several areas:

- Design and construction of large detectors
- Cryogenic systems
- Construction of large are wire chambers
- Custom designed readout electronics
- High performance data acquisition
- High volume data storage and analysis
- Project management

Fermilab would need to play a major role in the overall engineering design of the detector and it will act as an intermediary between the industry (providing storage tank, cryo and purification systems). Fermilab will coordinate the construction and commissioning of the detector. The Lab will supervise development and production of customized readout electronics.

Computing Division would need to provide the data storage and the data access and organization tools.

Expected resources usage (very rough guess):
Engineers - 20 man-years
Technicians – 50 man-years
Physicists – 50 man-years
Managers – 20 man-years
Workshops, machine shops, cryo labs…

Such an experiment would greatly strengthen the physics case for the Proton Drive, which, in turn is likely to be indispensable for the studies of CP violation in the neutrino sector.